The ecological restoration of Otamahua/Quail Island 1. The island's physical setting and history, and planning for ecological restoration

Ray Genet and Colin J. Burrows

Department of Plant and Microbial Sciences, University of Canterbury, Private Bag 4800, Christchurch, New Zealand

(Received 15 March 1999, revised and accepted 6 October 1999)

Abstract

The land vegetation and faunal composition on Otamahua developed during at least 500 years of human influence. Fire cleared the original woodland prior to 1800 A.D. and will have profoundly modified the original fauna. During the European era selective grazing by domestic stock and rabbits and replacement of indigenous species by introduced grasses, shrubs, trees, birds, mammals and invertebrates created the modern, predominantly non-indigenous biotic complex.

Similar sites in Canterbury carry mixed indigenous coastal woodland. The environment of Otamahua is still favourable for native organisms and an earlier attempt at native woodland planting (early 1980s) was partially successful, in spite of inroads by rabbits and sheep. These facts have encouraged a new ecological restoration initiative.

The Otamahua/Quail Island Ecological Restoration Trust (and advisory committee) was set up in 1998, with support and material help from the administering body, the Department of Conservation and approval from the Rapaki runanga. The aim of the Trust is to carry out extensive native woodland plantings on the island and ultimately to reintroduce birds, lizards and invertebrates that are locally extinct, or rare.

Progress with the project so far includes successful fund-raising and publicity; removal of rabbits and cats (and possibly rats and mice); an initial small planting in 1998 and a larger one in 1999; preparation of an interim working plan and pest plant and animal control plans for operations in the immediate future. A preliminary archaeological survey has been done, a flora and brief vegetation description have been compiled, studies of birds, lizards and land invertebrates have begun, and longer-term planning for planting and ecosystem management is proceeding. Its freedom from feral predatory and browsing mammals makes Otamahua a unique and very important locus for nature conservation in Canterbury.

Keywords: flora - fauna - human disturbance - introduced organisms - ecological restoration - planted native woodland - native birds - lizards - invertebrates - unique - nature conservation

Introduction

Otamahua/Quail Island is an 85 ha public recreation reserve, situated near the head of the Lyttelton Harbour (Whakaraupo) and administered by the Department of Conservation in Christchurch. It also has important archaeological, historical and nature conservation values (Jackson 1990).

The terrestrial indigenous flora and fauna of Canterbury in general, and Banks Peninsula in particular, have suffered from severe assaults by

successive waves of human settlers, beginning with the original Polynesian arrival, probably about 700 years ago, and continuing to the present. Details are sketchy for the course of events before the European settlement (1830s-1850s). Some information can be adduced from palaeobotanical, archaeological and historical studies (Molloy *et al.* 1961, Petrie 1963, Brailsford 1981, Moar & Mildenhall 1988, Thomas 1989, Ogilvie 1990, Tremewan 1990, Burrows 1994, Wilson 1998). There is evidence for impacts of fire and introduced organisms, with consequent loss of vegetation and vertebrate animals. Invertebrates will have suffered, too, as much of their habitat was destroyed. The land around Lyttelton Harbour was affected and it is assumed that the same influences were experienced on Otamahua (Fig. 1).

In the mid 19th century Otamahua was mainly covered in indigenous grassland (Ward 1851). The main indication that the island had been well-wooded a few centuries earlier is the presence of low indigenous forest on similar dry sites around Lyttelton Harbour, elsewhere on Banks Peninsula and in North Canterbury (Genet 1997). Some of this forest contains a varied assemblage of woody species, angiosperm herbs and ferns, but in most of it the species composition is relatively simple (Table 1). Although Otamahua's native vegetation cover and flora are now much attenuated through the impacts of burning, grazing by domestic stock and rabbits, and competition from introduced plants, some remnants of woody vegetation still survive on

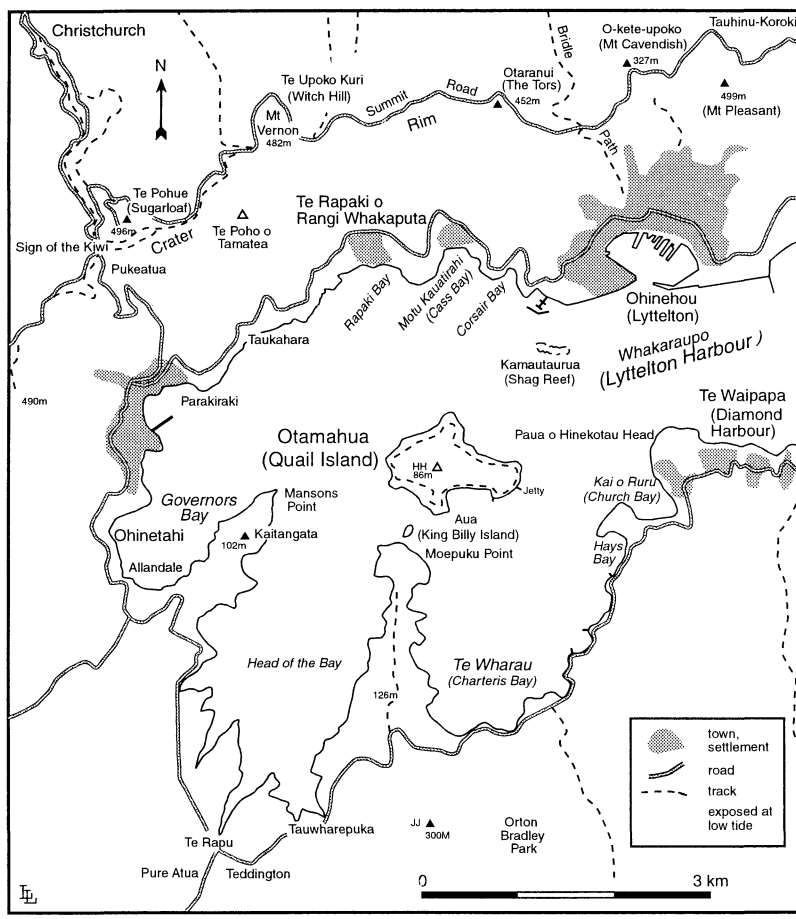

Figure 1 Otamahua/Quail Island in Whakaraupo (Lyttelton Harbour).

the island. The species composition of what remains resembles that of locations where more of the woody indigenous plant cover is still present.

In several parts of New Zealand offshore islands, which have experienced loss of their native plants and animals and introduction of foreign species, have been chosen as sites for ecological restoration (i.e. attempts to redevelop the native vegetation and fauna). Examples are Tiritiri Matangi in the Hauraki Gulf (New Zealand Department of Lands & Survey 1982) and Mana, off the Wellington west coast (New Zealand Department of Lands & Survey 1986). The motivations for wishing to restore native ecosystems on islands are manifold. One strong reason is that the chosen islands are circumscribed, relatively small areas. Harmful introduced animals and plants can be more easily controlled on them than on mainland locations where reinfestation is likely.

The general desire of New Zealanders to restore native ecosystems, on islands or elsewhere, seems to have developed from deep feelings about the need to preserve our unique biological heritage and to prevent further decline and loss. It is also about making amends, to some extent, for the gross acts of destruction caused by our forebears. Also, the planting of trees and consequent encouragement of birds and invertebrates is very positive. It helps people to feel more at one with nature. Such efforts are desirable where humans are increasingly divorced from the natural world by technology and the exigencies of living at a frenetic pace, in an artifact-dominated environ-

Table 1 Examples of plant species in mixed coastal woodland on Banks Peninsula and North Canterbury.

Species-rich (Shaded, relatively moist sites)		
Trees		
	Cordyline australis ti-kouka	*Pittosporum eugenioides* lemonwood
	Dodonaea viscosa ake ake	*P. tenuifolium* kohuhu
	Griselinia littoralis broadleaf	*Plagianthus regius* manatu
	Hoheria angustifolia houhere	*Podocarpus totara* totara
	Melicytus ramiflorus mahoe	*Pseudopanax ferox* fierce lancewood
	Myoporum laetum ngaio	*Sophora microphylla* kowhai
	Myrsine australis mapou	
Shrubs		
	Coprosma crassifolia thick-leaved c.	*Hebe strictissima* stiff hebe
	C. propinqua miki-miki	*Macropiper excelsum* kawakawa
	C. robusta karamu	*Melicytus alpinus* whare-karara
	C. virescens green-seed c.	*Solanum laciniatum* poroporo
	Corokia cotoneaster korokio	*Urtica ferox* ongaonga
Vines		
	Calystegia tuguriorum N.Z. convolvulus	*Muehlenbeckia australis* pohuehue
	Clematis foetida lemon clematis	*Parsonsia capsularis* aka-kiore
	Rubus squarrosus lawyer	*P. heterophylla* aka-kiore
Herbs, Ferns		
	Asplenium terrestre ground spleenwort	*Polystichum richardii* dark shield fern
	Pellaea rotundifolia round-leafed fern	*Uncinia leptostachya* dark hook-sedge
Species-poor (Exposed, drier sites)		
Trees		
	Kunzea ericoides kanuka	*Sophora microphylla* kowhai
Shrubs		
	Coprosma rhamnoides variable-leaved c.	*Muehlenbeckia complexa* pohuehue
	Helichrysum lanceolatum niniao	*Olearia paniculata* golden ake ake
Herbs, Ferns		
	Arthropodium candidum dainty lily	*Microlaena stipoides* small rice grass
	Asplenium flabellifolium fan fern	*Polystichum richardii* dark shield fern

ment. Further, there are aesthetic motives in ecological restoration. The organisms being fostered are beautiful in a variety of ways.

In the Canterbury region, Otamahua is the only sizeable island (85 ha) which might serve as an appropriate site for ecological restoration. Its location in Lyttelton Harbour makes it accessible and visible. Proximity to a relatively large population is beneficial, also, in various ways. The island, a Recreation Reserve administered by the Department of Conservation, is popular mainly for picnics, swimming, walking and boat-associated activities. Its importance to the tangata whenua, the Ngai Tahu people at Rapaki, will be considered later. In due course the island's value as a natural history teaching and learning resource will increase greatly. The present account describes the environment of the island and the history of human activities, in relation to ecological restoration. The origins of the restoration project and developing ideas on how it could proceed are briefly summarised.

The Environment of the Island

Rocks, landforms

Otamahua is a plateau-like, isolated fragment of a superimposed series of volcanic deposits near the southern end of the Lyttelton caldera (Fig. 1, 2). Its maximum height above sea level is 86 m and, at the plateau margins slopes fall

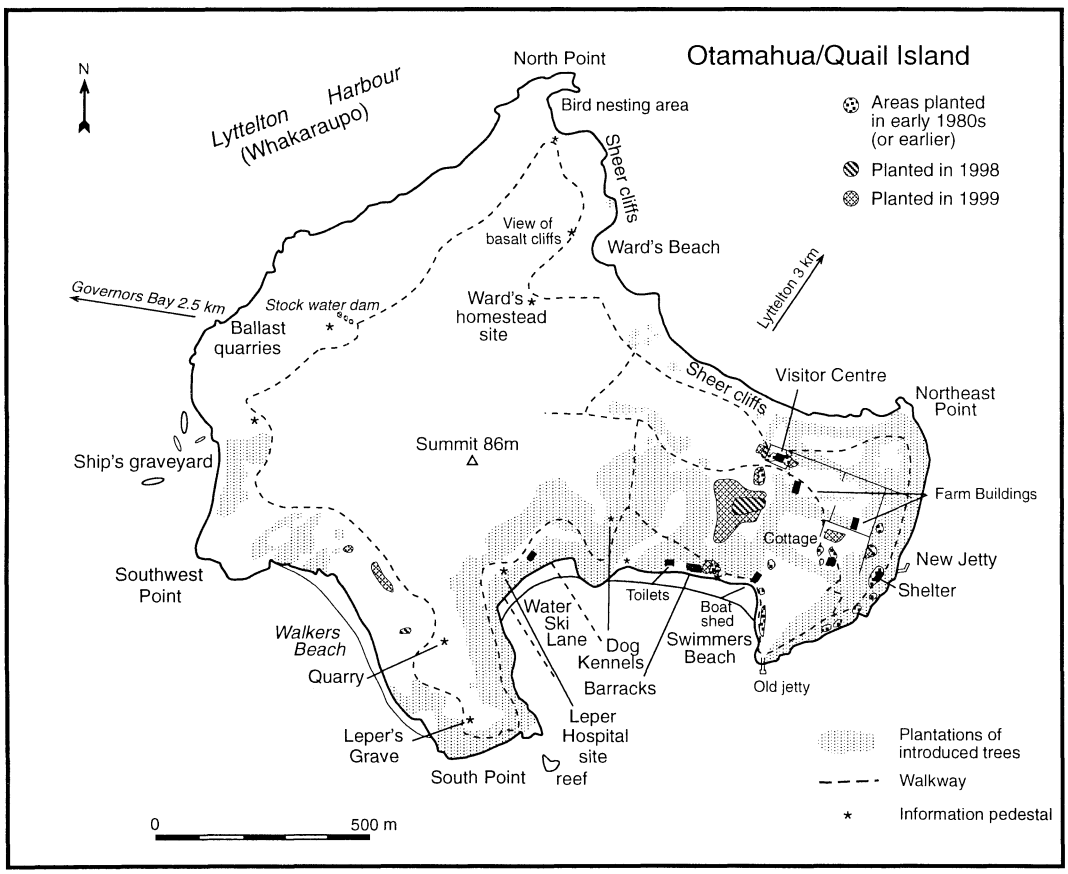

Figure 2 Locations, main non-indigenous plantation areas and the indigenous planting areas 1980s, 1998 and 1999.

steeply to the sea, especially on the NE, where there are high, precipitous cliffs. On the NW and E the cliffs are lower. The S and W margins are generally much less steep, though some cliffs are present.

The sequence of volcanic rocks from oldest to youngest is: pale-coloured Allandale rhyolite (early Miocene) cropping out mainly along the S coast; Darra basanitoid (columnar basalt) on W and E, with some surface outcrops on the plateau; Church basalt (N) and Stoddart basalt (NW). The last three are dark-coloured and late Miocene in age (Sewell *et al.* 1993). Cliffs on the NE coast expose alternating layers of basaltic lava and conglomerate, with some rhyolite near sea level.

The summit plateau is generally covered by a layer of yellowish loess varying from a metre or so to more than 20 m thick. It was deposited during the late Quaternary. Below the plateau minor landslides, gullying and tunnel erosion are evident in the loess on the S and W of the island.

There are no streams on the island, but shallow valleys carry drainage water off the plateau on the NW and NE. The depression where the stock dam has been formed (Fig. 2) may have carried a natural transient pond before European settlement. Seepages occur in a few places at the contact between the loess and the volcanic rocks, or emerge from natural fissures in the bedrock. A small but steady trickle of water is maintained.

Wave-eroded shore platforms occur wherever the bedrock meets the sea. They are especially well developed on the NE and E coasts, where there are also extensive boulder beaches. On the S, W and NW are small, narrow plains developed on shore deposits a metre or more above high tide level. They may have been formed during the mid-Holocene high sea level episode (Brown & Weeber 1992). Muddy sea floor deposits and narrow, shelly beaches are present on the S, W and NW of Otamahua. The upper Whakaraupo (Lyttelton Harbour) basin is shallow, with maximum depths of 5-10 m at high tide. At low tide extensive mudflats join Otamahua to the nearest headland on the mainland, Moepuku Point to the S (with tiny Aua, or King Billy islet between it and Otamahua). A shallow channel often lies around the northern end of Moepuku Point and may cut off direct low tide contact with the mainland.

Soils

No definitive soil surveys appear to have been done for Otamahua. The main parent material is loess. Basaltic and rhyolitic rocks are also important parent materials and mixtures of more or less weathered bedrock with loess are common. Soils on loess are of variable depth, drainage capabilities (due to site) and degree of development of structure and organic content in the A horizon. Wherever grasses dominate in the vegetation these soil properties are recognisable in the field by the specific combinations of plants that are present (see Burrows *et al.* 1999). Very well drained soils occur around the margins of the plateau and in places where the loess thins out over bedrock. They are black, highly organic, with fine crumb structure, and presumably fertile, but usually shallow. Other relatively well drained soils occur on loess on slopes on the flanks of the plateau. These, and soils derived from rhyolite, have weak development of structure (they may be massive) and weak organic A horizon development. They are assumed to be relatively infertile.

By contrast, soils on much of the top of the plateau, on level and gently sloping sites, and beneath basalt outcrops on south-facing aspects, retain moisture, have strongly developed crumb to nutty structure, and relatively thick, black A horizons. They are assumed to be relatively fertile.

In hollows and valley floors on the summit plateau moisture accumulates in winter. The B horizons of the soils are more or less gleyed and the wettest are massive in structure. These sites appear to be relatively infertile, judged by the grass species which inhabit them and the lack of

a black, well structured A horizon.

On the NE coast some shallow, loose, well drained soils are present on talus areas under the cliffs, with mixtures of silt and angular pebble-, or cobble-sized clasts. Some firm, well-structured soils lie immediately above basalt or conglomerate bedrock on dry sites on the NE coast. Their brown colour derives from their origin from weathered bedrock. On ledges sea-bird guano may be incorporated into these soils.

Shore deposits on S and W of the island are stony and have shallow, black soils, rich in organic matter. Shelly gravel and sand form a distinctive soil along the strand on the S.

Climate

No long-term weather records have been kept for the island. It has hot, dry summers and cool, moist winters. Based on records for nearby mainland stations Allandale (head of Lyttelton Harbour), Lyttelton and Christchurch (N.Z. Meteorological Service 1963,1963-73, 1983, 1984; Ryan 1987), mean annual temperature at 1.5 m above the ground will be about 12°C, with range from about -5° to 35°C. There will be about 30 days of ground frost, but very rare snowfall. Annual average precipitation will be about 68 cm, on 90 rain days. In most years drought occurs January-February-March and periodically there are longer, intense droughts. The island is exposed to wind and sometimes experiences easterly and southerly gales. Wind directions are mainly NE to E (38% of days of the year) and S to SW (26%); 23% of days are calm.

No microclimate information is available; clearly moisture retention in the soil is greatest and evapotranspiration least on the S to SE-facing aspects and in some level sites and hollows on the plateau.

Plant and animal life

Introduced grasses, forbs, patches of shrubs and planted conifer and deciduous angiosperm woodland form about 90% of the vegetation cover on Otamahua. However, subtly interwoven with this are indigenous plants. There are, in particular, significant areas of grassland, scrub, fernland and some treeland where native species predominate. Many vertebrate animal species and a considerable proportion of the invertebrates are also introduced. However the bird and invertebrate faunas are still rich in native species (M. Bowie, pers. comm.). The vertebrate animals are listed later in this article and more about flora and vegetation is included in Burrows *et al.* (1999).

History of the Island

Maori period

Although records are sparse for Otamahua from the period before European contact in the region, the Ngai Tahu people at Rapaki maintain orally-transmitted tradition about the island (W. Gillies, pers. comm.). Archaeological remains on the island include umu and finished and unfinished stone tools (Jackson 1990). In the early 19th century there may not have been continuous occupation by the tangata whenua, but Ward (1851) noted the presence of a "Maori house" on the west side of the island. It is thought to have been used for overnight shelter (Jackson 1990).

"Otamahua" refers to the gathering of sea-bird eggs on the island by the tamariki (Jackson 1990). An older name, recorded on the map prepared by Fournier (1838) was Te Kawakawa, presumably in reference to the pepper shrub *Macropiper excelsum.*

Traditionally the island was an important mahinga kai area where shellfish were gathered and fish caught. A stone fish trap system has been discovered recently on the mudflats to the S of Otamahua (C. Jacomb, pers. comm.).

The Rapaki people retain customary rights, or mana whenua, over Otamahua. The island is of great spiritual and cultural significance to them. Their interest is in the whole island, including its shoreline, seabed and the surround-

ing waters (W. Gillies, pers. comm.).

European period

Otamahua, or Quail Island (named so by W. Mein Smith, in reference to the presence of the now extinct native quail [*Coturnix novaezelandiae*] which was present there in 1842 – citation by Wakefield 1848) was acquired by the Crown, from Ngai Tahu, in 1850 (Jackson 1990). The brothers Ward (Ward 1851) began farming on the island in 1851. The first stock included dairy cows, goats and pigs, and rabbits were first introduced at this time, also.

From then on the island was used for farming, chiefly with sheep, in the periods 1852-55, 1858-63, 1887-1949, 1958-85. The Ward's homestead was on the plateau above the N coast, but was relatively difficult of access. Subsequently farm buildings were sited on the plateau at the SE end of the island and a jetty was built on the SE coast (Jackson 1990) (Fig. 2).

By about 1890 the plateau area had been fenced into paddocks and conifer windbreak plantations were established. Crops were grown in some of the paddocks, but otherwise they were sown in pasture. The island was also used as a human and animal quarantine area (c.1875-1931), with buildings near sea level, at the SE end (Fig. 2). Much of the southern side of the island, near these buildings, was planted with extensive groves of conifers and deciduous trees. Most of these were well established by 1907 (Jackson 1990).

In 1976 Otamahua become a Recreation Reserve, administered by the Department of Lands and Survey. Farming activities ceased in 1985 (Claire Findlay, pers. comm.), and the Department of Conservation took over management in 1987. As noted earlier the island is a popular recreation area for day visits. Only limited overnight stays (school camps and the like) are permitted. Launches on the passenger run from Lyttelton to Diamond Harbour visit the island on demand. Water is supplied by pipeline from Lyttelton and there is a sewage effluent treatment system on the island.

Genesis of the Otamahua/Quail Island Ecological Restoration Project

In 1996-1997 R.G. undertook research for an M.Sc. in Environmental Science at the University of Canterbury, investigating the potential of Otamahua as a site for ecological restoration (Genet 1997). The notion that an ecological restoration project could be viable arose from his observations that the sparse native woody cover of the island has held its own (with some species gradually increasing) in spite of almost 150 years of grazing by stock and feral rabbits, and invasion by many foreign plant species (Burrows *et al.* 1999).

In fact, there was an earlier attempt at ecological restoration on Otamahua. In the early 1980s staff of the then Department of Lands and Survey carried out extensive plantings of native trees and shrubs. However, of the thousands of plants put in, only a few hundred survived, principally because of inability to keep rabbits well controlled. They, and incursions of domestic sheep into planted areas, severely damaged the plantings (Claire Findlay, pers. comm.). C. Meurk (1990) made some suggestions to the Department of Conservation about revegetation of Otamahua with native plants, and animal introductions, which were not taken up.

The success of the plants which survived rabbit depredations and the observation by R.G. that numbers of these species have begun to regenerate spontaneously, provided further motivation for renewed efforts for ecological restoration of the island. The species involved are indicated in Burrows *et al.* (1999) which also records other aspects of botany of Otamahua.

R.G.'s thesis study also included the animal components. Before it was deforested by fire, Otamahua would have had a rich complement of native land animals (birds, lizards and invertebrates). The native land vertebrate populations are now low in numbers and diversity (Table 2).

The indigenous land invertebrate fauna is still quite diverse (with various insect groups, arachnids, crustacea, molluscs, earthworms, etc) and an inventory is being compiled by Lincoln University zoologists (M. Bowie, pers. comm.).

R.G.'s (1997) study included the development of a comprehensive plan for planting about half of the island's surface in native woodland, in at least two phases. An initial cover of very hardy species would be developed. Then, in the most favourable sites a wider range of species would be put in when the earlier-planted species were well established and beginning to spread, naturally (Table 3). R.G. also advocated reintroductions of some bird and lizard species (Table 4).

The environmental disadvantages of Otamahua for ecological restoration were carefully considered by R.G. The most serious problems: shortage of water in summer (which would make plant establishment difficult) and the large rabbit population were, he suggested, surmountable. Various other aspects, philosophical, organisational and financial, of an overall scheme for ecological restoration of Otamahua were also considered by R.G. When his research project concluded he discussed with Department of Conservation staff the possibility of implementing a restoration scheme on the island. They responded positively and a public meeting was called by the Department, in mid 1997, to test the degree of support among groups and individuals who might be interested. The idea was well received and a steering committee was set up to begin planning for the project, including the establishment of a Trust to organise it and a technical advisory committee. A booklet was prepared summarising the main points of R.G.'s thesis and explaining how ecological restoration might be done (Genet & Burrows 1998).

The Otamahua/Quail Island Ecological Restoration Trust was legally constituted during

Table 2 Land vertebrates on Otamahua. 1, removed during 1998-99; 2, rare visitor.

A. Mammals (all introduced)	
Erinaceus europaeus hedgehog	*Oryctolagus cuniculus* feral rabbit[1]
Felis catus feral cat[1]	*Rattus rattus* ship rat[1]
Mus musculus mouse[1]	
(N.B. *Mustela erminea*, stoat and *M. putorius*, ferret were present in the past but none have been seen recently)	
B. Birds (includes some seabirds and waterfowl)	
Native or self-introduced	
Anas superciliosa grey duck	*Larus dominicanus* black-backed gull
Anthornis melanura bellbird	*L. scopulinus* red-billed gull
Ardea novae-hollandiae white-faced heron	*Phalacrocorax melanoleucos* little shag
Zosterops lateralis silvereye	*Rhipidura fuliginosa* fantail
Circus approximans harrier	*Sterna striata* white-fronted tern
Gerygone igata grey warbler	*Stictocarba punctatus* spotted shag
Haematopus finschii pied oystercatcher	*Tadorna variegata* paradise shelduck
Hemiphaga novae-seelandiae kereru[2]	*Eudyptula minor* blue penguin (white flippered form)
Introduced	
Alauda arvensis skylark	*Embiriza citrinella* yellowhammer
Anas platyrhynchos mallard	*Fringilla coelebs* chaffinch
Athene noctua little owl	*Gymnorhina hypoleuca* white-backed magpie
Branta canadensis canada goose	*Lophortyx californica* california quail
Carduelis carduelis goldfinch	*Passer domesticus* house sparrow
C. flammea redpoll	*Sturnus vulgaris* starling
Chloris chloris greenfinch	*Turdus merula* blackbird
Columba livia rock pigeon	*T. philomelos* thrush
C. Lizards (both native)	
Hoplodactylus pacificus common gecko	*Leiolopisma zelandica* common skink

Table 3 Woody species for planting on Otamahua.

First Phase	
Most of the species listed in Table 1, and *Phormium tenax*, harakeke, a large monocotyledonous herb, *Leptospermum scoparium*, a shrub and *Myrsine australis*, a small tree.	
Second Phase	
Trees	
Alectryon excelsus titoki	*Pseudopanax arboreus* five-finger
Melicytus ramiflorus mahoe	*P. crassifolius* lancewood
Prumnopitys taxifolia matai	
Trees for the moistest sites	
Aristotelia serrata wineberry	*Hedycarya arborea* pigeonwood
Carpodetus serratus marble leaf	*Pennantia corymbosa* kaikomako
Fuchsia excorticata kotukutuku	*Streblus heterophyllus* turepo
Shrubs	
Coprosma areolata marble-leaved c.	*Cyathodes juniperina* mingimingi
C. lucida shining c.	*Lophomyrtus obcordata* myrtle
C. rotundifolia round-leaved c.	*Macropiper excelsum* kawakawa
Coriaria arborea shrub tutu	*Melicope simplex* poataniwha
Vines	
Clematis paniculata white clematis	*Tetrapathaea tetrandra* passion vine
Ripogonum scandens supplejack	
Shrubs and Vines for open sites	
Clematis afoliata leafless clematis	*Rubus squarrosus* var. *afoliata* leafless lawyer
Hebe strictissima stiff-leaved hebe	*Rubus schmidelioides* lawyer
Sophora prostrata dwarf kowhai	

Table 4 Suggestions for vertebrate introductions.

Birds	
Acanthisitta chloris rifleman	*Cyanoramphus novaezelandiae* red-crowned kakariki
Petroica australis South Island robin	*Prosthemadera novaeseelandiae* tui
P. macrocephala South Island tomtit	*Ninox novaeseelandiae* morepork
Lizards	
Naultinus gemmeus jewelled gecko	*Oligosoma lineoocellatum* spotted skink

1998 (see Appendix 1). The Trust is supported by and has legal ties with, and obligations towards, the Department of Conservation. Its members and members of its advisory committee, are volunteers. It has successfully raised funds for the project and organised publicity and work parties for physical tasks. An interim working plan for the project has also been prepared (Findlay & Associates 1998).

Progress so far with the new restoration scheme

One vital initiative was control of rabbits on the island. In November 1997 the Canterbury Regional Council was contracted by the Department of Conservation to carry out pindone bait drops, by helicopter. They proved to be very effective, such that only about a dozen rabbits were thought to have survived. The Department then employed specialist pest killers to remove them, during three periods in early 1998, by dogging and night shooting. At these times also, the feral cats on the island were shot (Brown 1998). Since these operations there have been no signs of cats, stoats, ferrets or mice on the island.

Checks in early 1999 revealed rabbit sign in three places. So far, two more rabbits have been killed and further efforts are to be made to get any that remain (Brown 1999). At the old Leper Hospital site (Fig. 2) a heap of empty walnut

shells was found in January 1999 (C.J.B. field notes). The tooth marks on the shells are consistent with feeding by ship rats (*Rattus rattus*) and the shell hoard appears to post-date the pindone poisoning. More monitoring will be done to discover whether rats are still present. The main pest mammals left now are hedgehogs. These animals eat large numbers of invertebrates, and the eggs of ground-nesting birds. A programme for their eradication is being contemplated.

In the winter of 1998 the first planting of indigenous trees and shrubs was done, around the visitor information centre; nearby, on a shady aspect under a basalt outcrop; and above Walkers Beach (Fig. 2). The 1300 trees and shrubs put in (mainly by volunteers) included a similar mix of species to those planted in the early 1980s (Burrows *et al.* 1999). Before planting the grass sward was cleared by "weed-eater", herbicide, or chipping with a spade. Losses of plants over the following year (during periods of severe summer and autumn drought) are estimated to have been no more than about 4%. Most occurred in hot, dry sites.

In June-July 1999 nearly 7000 young native plants have been put in, almost all in the same general locations as for the 1998 planting (Fig. 2 and see Burrows *et al.* 1999). Similar numbers of plants will be established, progressively, in each future year for at least the next decade. The work was done, on six main planting days, by volunteers from the general public and Catholic Cathedral College, and by some Department of Corrections workers. The Trust employed a supervisor, Mr John Watson, to oversee the many planting and aftercare tasks.

During 1998-early 1999 a comprehensive list of vascular plant flora and a brief vegetation description were prepared for the island (Burrows *et al.* 1999). A weed control plan was also prepared (Burrows in press) and some weed clearance begun, aimed initially at containing the spread of woody species by killing the adults. Volunteer workers, Department of Conservation staff and Department of Corrections Conservation Corps workers are doing the weed removal tasks.

Zoological work includes bird studies by Ms C. Troup, lizard studies by Ms K. Lukis and land invertebrate studies by a team from Lincoln University under the leadership of Dr M. Bowie.

In 1999 longer-term planning for the planting programme and animal components of the restoration project will be done. The ecological restoration of Otamahua seems to be well and truly under way. The planting scheme differs from R.G.'s original plan (Genet 1997) to the degree that a wider variety of species is being put in at the outset. Generally the most favourable locations (shaded, with relatively moist, deep soils) have been chosen for planting. However on the driest sites within these, only very hardy species are planted. Enrichment of the well-grown indigenous plantings from the 1980s is being done, wherever possible.

Conclusions and Possible Future Developments

By virtue of the removal of browsing and predatory mammals, Otamahua has become a unique and very important locus for nature conservation in Canterbury. The main aim of the restoration project is to tip the balance in favour of indigenous woodland, which, within about 20 years, will replace introduced grassland over, perhaps, 30% of the island's surface. This will require a constant input of labour and money both for planting and subsequent after-care of the plants until they are big enough to suppress the existing grassy sward.

As the planted woodland develops and the canopy closes (as is evident in patches of trees planted in the 1980s) the presently pervasive grassland on the planting sites, mainly on the shaded aspects of Otamahua, will be suppressed. Within one to three decades self-seeding by the newly planted trees and shrubs will begin. Ultimately the woodland will be self-sustaining (cf. Burrows *et al.* 1999). The general habitat condi-

tions that prevail from then on will allow underplanting of some more sensitive native species including certain ferns and angiosperm herbs.

Eventually the recreation of native grassland on parts of Otamahua may be attempted. This will be difficult because of the constant threat of invasion by introduced herbaceous plants, especially grasses. It could only be done on a small scale. Another possibility would be to develop a garden on Otamahua in which rare or threatened plants of our region are grown e.g. *Muehlenbeckia astonii*, *M. ephedroides*, *Olearia fragrantissima*, *Senecio sciadophilus*, *Teucridium parvifolium*.

When sufficient area of indigenous woodland has been established on the island the next phase of ecological restoration can be considered, namely the introduction of forest birds such as tomtits *Petroica macrocephala*, robins *P. australis*, and tui *Prosthemadera novae-seelandiae* that are locally extinct. Introductions of lizards and invertebrates will also be contemplated. In the meantime planning for management to improve the lot of some birds (gulls, *Larus dominicanus*, *L. scopulinus*, and blue penguins, *Eudyptula minor*) that already breed on the island, could be done. Also, management to enhance the conditions for invertebrate animals may be possible.

The marine ecosystems around Otamahua have barely been considered, so far. Their study should be initiated. As Otamahua/Quail Island is a recreation reserve, but also has important associations for the tangata whenua, as well as archaeological, historical and nature conservation values, independent of the ecological restoration that is now in train, carefully integrated planning is needed to accommodate the diverse interests and avoid conflicts. The role of the runanga at Rapaki in this will be very important. Efforts are now being made by the Trust to develop a comprehensive framework of longer-term vision which will enable the public in general and the tangata whenua, in particular, to be drawn into the planning process.

Acknowledgements

The help of many colleagues in checking the script is gratefully acknowledged. We are indebted to Claire Findlay for information about events during the 1980s. Colin Meurk made useful suggestions for improvement of the text. Department of Conservation staff, particularly Robin Smith, John Trotter, Tony Woods and Richard Suggate have also been very helpful. Julia Burrows typed the script and Lee Leonard prepared the maps.

References

Brailsford, B. (1981). *The Tattooed Land.* Reed, Wellington.

Brown, D. (1998). *Quail Island Rabbit Eradication Project.* Final Report, June 1998.

Brown, D. (1999). *Quail Island Rabbit Eradication and Pest Management.* Trip Report 21-25 May, 1999.

Brown, L. J. & Weeber, J. H. (1992). *Geology of the Christchurch Urban Area.* (Text and map 1:25,000). Institute of Geological and Nuclear Sciences, Lower Hutt.

Burrows, C.J. (1994). Fruit, seeds, birds and the forests of Banks Peninsula. *New Zealand Natural Sciences 21*: 87-108.

Burrows, C.J. (in press). The ecological restoration of Otamahua/Quail Island. 3. Problem plants and their control. *New Zealand Natural Sciences 25*

Burrows, C.J., Wilson, H.D. & Meurk, C.D. (1999). The ecological restoration of Otamahua/Quail Island. 2. Terrestrial flora and vegetation cover of the island. *New Zealand Natural Sciences 24*: 127-150.

Findlay, C., & Associates (1998). *Operating Plan 1998-99 for Ecological Restoration of Otamahua/Quail Island.* Department of Conservation, Christchurch.

Fournier, J.M.M. (1840). Plan du Port Cooper. Dans la Presqu'lle de Banks (Nouvelle Zélande). Dépôt – general de la Marine. Chart

of Whakaraupo (Lyttelton Harbour) prepared in 1838 during the visit of the French warship *Héroïne.*

Genet, R.M. (1997). *The Development of a Concept Plan for the Ecological Restoration of Quail Island (Otamahua).* Unpublished M.Sc. Thesis , University of Canterbury, Christchurch, New Zealand.

Genet, R. & Burrows, C. J. (1998). *A Vision for the Ecological Restoration of Quail Island (Otamahua).* Rebus Publications, Christchurch.

Jackson, P. (1990). *Quail Island, a Link with the Past.* Department of Conservation, Christchurch, New Zealand.

Meurk, C.D. (1990). A reappraisal of and proposal for management of Quail Island. *D.S.I.R. Land Resources, unpublished report.*

Moar, N.T. & Mildenhall, D.C. (1988). Pollen assemblages from late Quaternary deposits in Canterbury. *New Zealand Journal of Geology and Geophysics 31*: 331-5.

Molloy, B.P.J., Burrows, C.J., Cox, E.J., Johnston, J.A. & Wardle, P. (1963). Distribution of subfossil forest remains, eastern South Island, New Zealand. *New Zealand Journal of Botany 1*: 68-77.

New Zealand Department of Lands and Survey (1982). *Tiritiri Matangi Island Working Plan.*

New Zealand Department of Lands and Survey (1986). *Mana Island Management Plan.*

New Zealand Meteorological Service (1963). *Summaries of Climatological Observations at New Zealand Stations to 1960.* Government Printer, Wellington.

New Zealand Meteorological Service (1963-1973). *Annual Meteorological Observations for 1960 to 1970.* Government Printer, Wellington.

New Zealand Meteorological Service (1983). Temperature normals for New Zealand, 1951 to 1980. *Miscellaneous Publication No. 183.* Government Printer, Wellington.

New Zealand Meteorological Service (1984). Rainfall normals for New Zealand 1951 to 1980. *Miscellaneous Publication No. 185.* Government Printer, Wellington.

Ogilvie, G. (1990). *Banks Peninsula: Cradle of Canterbury.* Government Printer, Wellington.

Petrie, L.M. (1963). *From Bush to Cocksfoot: An Essay on the Destruction of the Banks Peninsula Forests.* Unpublished M.Sc. Thesis, University of Canterbury, Christchurch.

Ryan, A.P. (1987). *The Climate and Weather of Canterbury.* New Zealand Meteorological Service, Wellington.

Sewell, R.J., Weaver, S.D. & Reay, M.B. (1992). *Geology of Banks Peninsula* (map 1:100,000). Institute of Geological and Nuclear Sciences, Lower Hutt.

Thomas, A. (1989). The Human and Pre-human Forest Landscape of the Lyttelton Harbour Basin: From the Late Otira Glacial to the Era of Early European Occupation. Unpublished Report, Department of Geography, University of Canterbury, Christchurch.

Tremewan, P. (1990). *French Akaroa.* University of Canterbury Press, Christchurch.

Wakefield, E.J. (1848). *The Handbook for New Zealand.* J. W. Parker, London.(Citation of report on Whakaraupo (Lyttelton Harbour) by W. M. Smith).

Ward, E. (1851). *Journal, 1850-51.* (Published in 1951). Pegasus Press, Christchurch.

Wilson, H. D. (1998). Living in Raoul country: the changing flora and vegetation of Banks Peninsula. In *Etienne Raoul and Canterbury Botany 1840-1996* (ed. C.J. Burrows), pp 101-121. Canterbury Botanical Society Special Publication.

Appendix 1. Summary of the deed for the Otamahua/Quail Island ecological restoration trust

The Trust was established for charitable purposes, on 15 March 1998, under the terms of the Trustee Act, 1956. The Trustees for 1998-1999 are Christopher John Potter (Executive, Christchurch); Wiremu Witute Gillies (Retired School Teacher, Rapaki); Christine Mary Troup (Research Biologist, Lyttelton) and Michael James Sleigh (Solicitor, Christchurch). The Trust's postal address is: P.O. Box 127, Lyttelton and the Secretary is Alison Ross.

Purpose of the Trust: The establishment of a fund and a team to promote, coordinate, manage and finance the ecological restoration of Quail Island in Lyttelton Harbour, and to educate the general public about this.

The Trust is subject to Trust Law generally and to the legal requirements for the care of funds, auditing, etc. Under its powers to delegate it has established an advisory committee of people knowledgeable and skilled in fundraising, publicity, local government, ecology, conservation and related matters (Noeline Allan, Colin Burrows, Crile Doscher, Claire Findlay, Alan Leckie, Neil McLennan, Colin Meurk, Lucy Ozanne, Kerry-Jayne Wilson, with Department of Conservation representatives Robin Smith and Richard Suggate).

N.B. The Trust has close relations with, and legal obligations towards the Department of Conservation in relation to matters of occupational health and safety, general activities on the island, conservation of plants, animals and natural features, historical and archaeological sites, fundraising and publicity. It also has close relations with Banks Peninsula District Council, and the runanga at Rapaki.

Accomplishments of the Trust so far include the accumulation of funds through grants and donations; mammal and weed control, planting of native trees and shrubs, ecological surveys; establishment of a newsletter and preparation of an information brochure and poster; recruitment of supporters for the ongoing work on the island; preparation of interim management plans for the project.